DOCUMENT RESUME

ED 421 345 SE 061 541

AUTHOR	Wang, HsingChi A.; Marsh, David D.
TITLE	Science Teachers' Perceptions and Practices in Teaching the History of Science.
PUB DATE	1998-04-00
NOTE	31p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Diego, CA, April 13-17, 1998).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Educational Strategies; Elementary Secondary Education; *Epistemology; *Knowledge Representation; Science Curriculum; *Science History; *Science Instruction; *Science Teachers; *Teacher Attitudes

ABSTRACT

The purpose of this study was to investigate teachers' perceptions of the instructional role of the history of science and their actual practices of teaching science from an historical point of view. Specifically, this study is intended to answer the following research questions: to what extent do science teachers agree with the proposed instructional approach as it relates to including the elements of the history of science? and, to what the extent to which science teachers' instructional practices as reported match up with the elements of the history of science inclusion? This paper presents a conceptual framework to guide the design of the History of Science Instructional Survey; methodology that includes sampling, instrumentation, and data collection; findings; and conclusions and implications. (Contains 51 references.) (DDR)

SCIENCE TEACHERS' PERCEPTIONS AND PRACTICES IN TEACHING THE HISTORY OF SCIENCE

HsingChi A. Wang
David D. Marsh
University of Southern California

A paper presented at the annual meeting of the American Educational Research Association in April, 1998

Introduction

Recent reform reports in science education propose the inclusion of the history of science as an important science curriculum element (American Association for the Advancement of Science, 1993; National Research Council, 1996). According to Rutherford and Ahlgren (1990), the history of science should be included in science education for two reasons: 1) concrete examples in the history of science can provide a meaningful context for both scientific information and the operation of the scientific enterprise, and 2) some scientific episodes are considered milestones of human civilization that can add to the appreciation of one's own cultural heritage. In short, including the history of science can play a role in humanizing science so as to address the diverse needs of today's multicultural society and to achieve the goal of "science for all."

There have been multiple efforts to humanize science in science education over the past 40 years. Three of these efforts are discussed as context for examining current efforts to humanize science education. The three historical periods include: 1) the golden age of science education: Post-Sputnik reaction; 2) science education for enlightened citizenry; and 3) standards-based science education reform.

The golden age of science education: Post-Sputnik reactions. The first period was known as the Golden Age of Science Education (Kyle, 1991), which was sparked by the *Sputnik I* launch. It resulted in innovative and spectacular changes in American science education. "Alphabet-soup" science curricula were nurtured by society's demands for more rigorous science education, in order that future scientists could compete with the pace of scientific research in the Soviet Union. For instance, Klopfer and Watson (1957) adopted and extended Conant's (1957) college textbook, Harvard Case Studies in Experimental Science, into History of Science Cases (HOSC) for high school science.

Efforts were made to humanize science education through the use of the history of science in this golden age. In 1962, Holton, Watson, and Rutherford proposed teaching high school physics through science history; thus, Harvard Project Physics (HPP) emerged and was actively adopted nationally. The HPP curriculum aimed at providing a cultural and humanistic experience for every student. Biological Science Curriculum

Study (BSCS) engaged in developing science curricula for elementary, middle, and high school biology classes based on two fundamental approaches: Science as Inquiry (Schwab, 1964) and Science and Humanity. Schwab's (1963) BSCS Teacher's Handbook emphasized an historical approach to show how the scientific framework arose and was tested throughout the history of science; it provided a "fair treatment of the doubts and incompleteness of science" (p.41). Schwab further asserted that the teacher ought to encourage students to understand that "[Science] history concerns man and events rather than concepts in themselves. There is a human side of [e]nquiry" (p.42).

Science education for enlightened citizenry. The call for an enlightened citizenry rather than an "educational elite" for society (DeBoer, 1991) initiated the second period of humanized science education. Under the banner of "science for all," humanistic reformers advocated curricula that are relevant and appealing to every student. The reform movement pushed for constructing a humanistic, value-oriented curriculum that would portray a wide range of personal, societal, and environmental concerns (National Science Teacher Association, 1982). Mascolo's (1969) and Welch's (1973) studies of humanistic science programs showed that these approaches have a positive impact on students' inquiry ability and science understanding. In addition, Quattropani (1977) found that the changes in the science curriculum significantly increased science enrollment. Unfortunately, the majority of practitioners still believed in traditional science instruction, which focused on content coverage rather than on genuine understanding of the nature of science. The humanistic approach to science education was almost extinguished as the "back to the basics" movement rose during the '70s and '80s.

Standards-based science education reform . The third period started with several reports in the early '80s on how poorly American students performed on science understanding tests, compared to pupils of other countries. The report A Nation at Risk (National Commission on Excellence in Education, 1983) called for changes in science education as necessary to boost American students' understanding of mathematics and science. A results-based, standards-based educational reform was initiated, in which several national efforts have been undertaken to propose standards for what students ought to learn and be able to perform in science. Wang and Marsh (1997) reviewed the "curriculum ideologies" (Eisner, 1985) in three educational standards documents, Benchmarks for Science Literacy (AAAS, 1993), National Science Education Standards (NRC, 1996), and Performance Standards (New Standards, 1997) and found that the humanistic approach in the science curriculum had been revived again.

Wang and Marsh (1997) find that this wave of new science curriculum ideology reflected on the standards documents heavily emphasizes Esiner's (1985) "Personal Relevance" and "Social Adaptation/Social Reconstruction" ideologies. Specifically, the history of science endorsed in the first nation-wide content standards document, Benchmarks for Science Literacy (AAAS, 1993), portrays two ideologies. First, science education should provide individuals with the tools to discover or solve things that relate to their personal interests. Humanizing science through historical vignette will enrich science learning experiences by associating the individual's experiences with the scientific figures'. In addition, inclusion of the history of science will also provide cultural awareness. Both aspects portray the Personal Relevance curriculum ideology. Second, Benchmarks emphasizes that science education must be relevant to both individual and societal needs. The history of science lays out the interplay of science and society and provides learners with more than academic achievement by acknowledging and valuing the individuals' personal interaction experiences with their environment.

Accordingly, the NRC elaborated on the content standards of Benchmarks, by adding standards for assessment, professional development, teaching, programs, and systems as they pertain to science education. Using the AAAS standards as a reference, the National Science Education Standards (NSES) states that an historical approach will "elaborate various aspects of scientific inquiry, the nature of science, and science in different historical and cultural perspectives" (NRC, 1996, p. 200).

Lastly, Wang and Marsh (1997) reviewed Performance Standards, whose science performance standards was prepared based on the content standards of both Benchmarks and National Science Education Standards (New Standards, 1997), in which students' performance and learning outcomes were explicitly envisioned. For instance, in Performance Standards, "Scientific Connections and Applications" states that by the end of high school, students demonstrate conceptual understanding in "science as a human endeavor, such as communication, cooperation, and diverse input in scientific research; and the importance of reason, intellectual honesty, and skepticism" (p. 133). This standard is closely associated with the advocacy of the history of science as a human endeavor.

Current Endeavors in Humanizing Science Education

With the science standards endorsed by policy-makers, Bybee (1996) states that "the actual curriculum materials, textbooks, and courseware … aligned with policies such as the national standards is an important feature of this aspect of reform" (p.8). As reviewed previously, the HPP and HOSC programs fell into disuse in late '70s. Yet, fortunately, with the revival of humanistic science education, Gerald Holton, chief director of the HPP, initiated a professional development program with other researchers to assist classroom teachers and future teachers in teaching the history of science (personal communication, 1997). Furthermore, BSCS continuously developed curricula which incorporated the history of science. In 1985, BSCS established a mission to provide leadership in science education by developing a new K-12 sequence of innovative programs. Along with the previous curricula – the elementary curriculum, Science for Life and Living: Integrating Science, Technology, and Health, and middle school curriculum, Middle School Science and Technology – a phase three curriculum entitled Biological Science: A Human Approach was released in 1996 for high school curriculum.

Recently, another emerging science history curriculum -- MindWorks was developed by WestEd in the Southwest Regional Laboratory with support from the National Science Foundation. The module is a series of history-based instructional supplements for introductory secondary physical science, such as historical reprint materials and video dramatizations that are specifically assisted by KCET, a public broadcasting television station. Becker (1997) reports that with the success of years of pilot studies in students' learning outcomes, as described in the NSES, MindWorks is a promising physical science curriculum module that can effectively help students to achieve scientific literacy through learning the science history.

Standards-based science education reform will need more than the documentation of science standards reports, and preparation of curriculum resources. There is a pressing need to investigate the readiness of science teachers to approach science teaching through the history of science, or at the least to include it in their science teaching. Such idea is explicitly stated in NRC's standards document (NRC, 1996). Ball and Cohen's (1996) idea of providing teachers with comfort and confidence in content, and the pedagogy of the content, was perceived as one crucial component of teachers' willingness to change their instructional paradigm for innovative teaching.

Purpose of the Study

The purpose of this study is to investigate teachers' perceptions of the instructional role of the history of science, and their actual practices of teaching science from an historical point of view. Specifically, this study is intended to answer the following research questions:

1. To what extent do science teachers agree with the proposed instructional approach as it relates to including the elements of the history of science?
2. To what extent do science teachers' instructional practices as reported match up with the elements of the history of science inclusion?

The organization of this paper is: presentation of a conceptual framework to guide the design of the *History of Science Instructional Survey*; presentation of the methodology that includes the sampling, instrumentation, and data collection; presentation of findings; and conclusions and implications.

Creating A History of Science Conceptual Framework

Rationale and Recommendations for the History of Science

The history of science authors contend that the generation of scientific knowledge is a dynamic process of knowledge generation with social, historical, psychological, and other contextual rather than purely abstract and formal determinants. Science is an enterprise in which dynamic change and alteration are the rules rather than the exceptions. The dynamic characteristic of science can help individuals to cultivate scientific habits of perception and to be capable of practicing rational thinking and logical reasoning. Mendelsohn, Weingart, and Whitley (1977) collected and edited research articles about Social Scientific Knowledge (SSK) and asserted that the history of science embodies information about how scientists, both as researchers and as members of society, have interacted with the scientific discourse, society, and government. Moreover, the manner in which scientific progress influenced the public is vividly portrayed in the history of science. Most of all, scientific research from different cultural perspectives can best be appreciated by studying the history of science.

Duschl (1993), however, reports that inclusion of the history of science has been advocated for more than thirty years. Specifically, one major voice for such advocacy was James Conant, a scientist and past president of Harvard University. Conant (1951) postulated that since every citizen is expected to have informal opinions on the relationships among government, education, and issues of scientific research and development. It is imperative that some appreciation of the past complexities of science and society be a part of the education of both scientists and non-scientists. Because of the increasingly scientific nature of our society and the individual needs of its members, every person must be scientifically literate in order to function effectively.

The historical approach to science education as proposed by Conant (1951) is a powerful tool for the enhancement of general understanding in science. The benefits of the history of science inclusion proposed by Conant match with Pella, O'Hearn, and Gale's (1966) findings in their research of scientific literacy. Pella, et al. (1966) analyzed one hundred documents devoted to scientific literacy research and concluded that scientific literacy is the understanding of (i) basic concepts of science; (ii) nature of science; (iii) interrelationships of science and the humanities; (iv) ethics that control the scientist in his or her work; (v) interrelationships of science and society; (vi) differences between science and technology. Klopfer (1969) thus concluded that the history of science will prepare a scientifically literate individual who develops understanding in the *conceptual, procedural*, and the *contextual* aspects of science. It is therefore proposed that: Students will understand the concepts, processes, and contexts of science through learning the history of science. This proposal is supported by the research studies, and is further discussed below.

History of Science for Conceptual Understanding

Recommendations for using an historical approach to enhance conceptual understanding of science are based on several arguments. These arguments for using a historical approach include several purposes: 1) to enrich the presentation of scientific knowledge; and 2) to emphasize the tentative nature of scientific knowledge. Each of these is discussed below.

Enriching the presentation of scientific knowledge. According to Rutherford and Ahlgren (1990), teaching science for conceptual understanding must emphasize how science knowledge was constructed, and avoid practices of recalling concepts, ideas, explanations, laws, or theories. The history of science elements provides contextual information of what definitions, ideas, concepts, and theories of science prevailed at various moments of history. What the historical definitions about scientific ideas, thoughts, schemes were, and; how the history justified what scientific or pseudo-scientific ideas, and based on what arguments. These distinctions can be clearly presented through information such as the historical development of scientific knowledge.

As asserted by Kaplan, (1964), Kuhn (1970), and Schwab (1960), it is the process of determining which criteria "count" that distinguishes scientific knowledge. Through the exposure to science history, students can learn systematic and scientific methods for generating scientific knowledge. For example, what counts as an idea or explanation for any individual, scientist, or scientific community may not satisfy another individual, scientist, or scientific community. What makes a concept either unacceptable or appear to be correct are the criteria scientists employ in their investigations and evaluation processes. The criteria employed by scientists determine the standards for measuring, for initiating important research questions, for designing experiments, for filtering data, and for accepting the outcomes of an investigation. This adoption of criteria plays a crucial role in the growth of knowledge in science.

Emphasizing the tentative nature of scientific knowledge. The effect of history of science instruction for facilitating conceptual understanding is that the history of science reveals how a new conceptual scheme replaces an older one, and how two schemes can conflict with one another. The history of science presentation that provides evidence of scientific concept revolution can facilitate the tentative nature of scientific knowledge. According to Kuhn (1970), even though the transition from old scheme to new scheme was more tangled in its process, the process itself shows that scientific theories are apt to be tenacious. Kuhn further asserted that there was no set of rules to specify how the next scientific advance would be made.

Unfortunately, science educators found that this tenacious characteristic of scientific knowledge is commonly treated as a non-issue in traditional science instruction. Duschl (1990) characterized traditional science instruction as a "final form science" approach. This misleading approach transformed science classroom activities into practices of the "scientific method" to justify what was known. The dynamic and tenacious characteristics of scientific knowledge were diminished under such practices. Along with many other educators, Duschl (1990) and Matthews (1994) recommends to introduce the history of science to assist students learn the tentative nature of scientific knowledge.

History of Science for Procedural Understanding

The history of science can help build procedural understanding as well. Specifically, it can help enhance: 1) the process of thinking or thought experiment; 2) the process of investigation; and 3) the processes of concluding, inferring, elaboration, reporting, and application.

The process of designing experiments. Wartofsky (1968) elaborated that the growth of thinking is a process of formation, elaboration, and arrangement of ideas into a systematic, structural, and conceptual framework that combines and connects pieces of knowledge. Wartofsky has long studied historical works of science and described scientific knowledge as products of "systematic structures" formation processes. Educational psychologists have reflected Wartofsky's findings and proposed applications for science instruction (Anderson & Smith, 1986; Finley, 1983; Linn, 1986; Novak, 1977; Resnick, 1983). The instruction is based on the understanding that students develop their cognitive abilities by a process of progressively changing their conceptual schemes, the process is entailed in the history of science.

In addition, research also found that students who have higher levels of thinking or cognitive skills in a specific subject tend to form more systematized or integrated concepts (Gagne, Yekovich, & Yekovich, 1993). According to Hurd's (1973) and Aldridge's (1992), students in traditional science classrooms do not have opportunities to integrate and systematize what they learn when science was presented as discrete information. Current science instruction that focuses on teaching science as static facts has failed to assist learners to develop the cognitive abilities desired to construct their conceptual schemes.

In cognitive literature, an important topic appears repeatedly to assert that the conceptual development of children recapitulates some of the development of significant ideas in the history of science. Piaget (1970) hypothesized that there is a parallel between progress made in the logical and rational organization of knowledge and the corresponding psychological processes. Studies have provided substantial analysis of parallels (Champagne, Klopfer, & Anderson, 1980; Giannetto, Tarsitani, & Missoni, 1991; Wandersee, 1985) between scientists and students learning science. Brush (1974) long proposed that the historical approach gave teachers an opportunity to elaborate on the errors and mistakes that occurred in the process of concept development. The "mistakes," Wandersee (1985) asserts, help students attribute similar patterns in their own misconception of science learning to the historical cases. Students through this approach were found to be able to recognize their own conceptual misunderstandings (Griffiths & Barry, 1993). Recently, historical contextual information was found by Villani (1998) mapped closely to students' misconceptions in some complex scientific content like "special theory of relativity." Villani thus recommended that introducing historical moments of the theory development can assist conceptual change in students.

The process of investigation. Studying the history of science provides models for learning science as inquiry. Schwab (1960) learned from reviewing scientific research papers and recommended engaging students to acquire knowledge and science experiences by employing investigative procedures similar to those used by scientists.

Schwab (1962) further elaborated that teaching for inquiry is based on the proposition that science curricula should reflect not only scientific knowledge but also how knowledge is derived, which is, through various modes of inquiry, such as observing, measuring, modeling, explaining, and evaluating.

Duschl (1994) advocates the significance of observation, measurement, models, and evaluation is that each represents a sector of scientific inquiry determined by the theoretical commitments a scientist or a scientific community adopts when constructing a personal world view. Conant (1964) had long advocated case histories of science can present various ways in which new ideas have arisen from observation and experimentation, or new ideas have emerged within scientists' "intuitive hunches" through cognitive speculation on scientific information. However, most scientific concepts were generated from speculating about known ideas, observations, or experimental findings and eventually constructing a conceptual scheme; the intuitive hunch happens infrequently in the history of science. A dynamic investigation process learned from the history of science entails both "inductive" and "deductive" generating routes interchangeably (Brush, 1974).

The inductive route of scientific investigations describes science as progressing through the separation of "truth" from "error." Series of experiments ultimately induced scientific knowledge. Conversely, some major conceptual changes in the history of science resulted from philosophical arguments initiated before experimental investigation or verification. This was recognized as subjective behavior or a deductive route of investigation. When the history of science was closely scrutinized, it can be seen that these two scientific processes of generating knowledge both exhibit important impacts. Dyson's (1985) study of historical contributions to current understanding of the origin of life debates and provides a vivid example of these coexisting scientific research behaviors. Unfortunately, current science instruction often merely exercises the inductive process, asking students to perform a cook-book set of investigation processes to verify known facts. Such so-called "hands-on" laboratory work gives students an incomplete procedural understanding of science.

The process of concluding and inferring. In the history of science, scientific process includes not only thinking and investigation, but also reporting and application. Kaplan's (1963) work on scientific inquiry stressed that the process of inferring, elaborating, concluding, reporting, and application is another crucial elements but easily overlook. This is evidenced by the fact that scarcely research was found that provide study of teaching this aspect of scientific process in depth. Fortunately, with standards-based reform movement, there is a growing trend in education to emphasize students learn to draw conclusions based on data collected, make chart or graphic to clearly report findings of investigation, and propose applications of findings. Such process skills are important for both students who will enter scientific profession and students who will chose otherwise. Any scientific literate individual should be able to read graphics and understand how things work by applying their understanding of the principles behind the operation function.

History of Science for Contextual Understanding

The realm of contextual understanding refers to that through the history of science, students can learn: 1) the psychological factors involved in the science making. The history tells what motivated or inspired a scientist to sacrifice years of life and dedicate to scientific research. 2) The science history illustrates process of how scientists, both as researchers and as members of society, have interacted with the scientific discourse, society, or government to pursue and advance their research and to influence the general public. 3) There are various cultural factors associated to the science research was vividly presented when the science history being introduced. Such element can enhance cultural understanding.

This realm of understanding deals with issues of: Scientists possessed inquiry motives like any ordinary individual has when encounters things in daily life, and they worked diligently and persistently to search for the tools to satisfy their curiosity or meet initial motives. In addition, a closer look at the history, the interactions among scientists, how they behaved as team players, and how their devotion to the development of scientific knowledge got involved with other scientists and all their contemporary economic, political, social and cultural milieu.

Psychological factors. The history of science approach can also stimulate students' interests and positive attitudes toward science, which ultimately can bridge the "gap" between scientists and non-scientists as described by Snow (1962). The history of science literature includes scholarship on what motivated, inspired, or intrigued scientists to do research. For example, Einstein was intrigued by a toy his father gave him that made him want to understand more about the nature.

Content factors also include humanitarian concerns. For example, there are groups of scientists worldwide who are looking for methods to improving agricultural products or drugs to cure diseases to benefit human living condition. The history of science is abounded with these cases that can enhance students' understanding of the psychological aspects behind scientific research.

Sometimes, Scientific knowledge and scientists are perceived as dogmatic and inhumane. However, Matthews (1994) concludes that "History, by examining the life and times of individual scientists, humanizes the subject matter of science, making it less abstract and more engaging for students (p. 50)." Such powerful effect is the key to help reach the goal of science for all. Wandersee (1990) used historical vignettes as a science instructional approach and concluded that the students had a better understanding that there is a humanitarian side associated with scientific findings. Matthew (1994) recommends that the faces behind Boyle's law, Planck's constant, and Ohm's law be introduced from historical cases so that rather than stereotyping scientists, students are gaining a broader understanding of the lives and efforts of these scientists.

Social factors. The social aspect of scientific research is reflected in the history of science. The study of history brings future scientists to the realization that scientific investigations usually involve more than one investigator or laboratory and that the period of investigating time is often several years. However significant a single experiment may seem in retrospect, no important step forward in science sits solely on the record of any single investigator's observations. Rather, the interplay of ideas of several scientists or arguments between laboratories about experiments and their interpretation often mark the decisive turn into scientific thinking.

With increasing large-scale research projects, now more than ever, future scientists need to understand the role of discourse in the scientific community. Historical cases reflect the interplay within the intellectual community as well as with society and policy makers. How early scientists struggled and battled with the authority or entrenched thinking, both within and beyond scientific enterprises, provides today's scientists with a lesson: to realize that scientific research does not simply involve workers in the laboratories. In addition, scientists also have disagreement with each other, scientists discussed with each other, and scientific findings needed peer-review in order to be published and recognized.

Stereotypes of scientists and prejudices toward science result from inadequate communication between scientists and nonscientists. Scientists have to constantly step back and reflect upon how their science can help to improve the economy or society. Their ethical and moral standards in doing scientific research must be taken seriously, because scientists are supported by the general public to help improve the living environment. The communication will need mutual input. The general public will need to have sufficient scientific understanding to make proper judgement for support in science research.

Cultural factors. The advocate for the cultural aspect of understanding through the historical elements is based on Bandura and Walters's (1963) modeling theory in which individuals would benefit by observing others performing a task that they themselves would ultimately be asked to conduct. The history of science has portrayed role models from different cultures such as scientists from China, Egypt, England, France, Greece, Germany, Italy, and Japan. Cultural awareness can be learnt from the history of science and is best established through recognizing one's own cultural heritage.

In addition, the works of female scientists such as Curie's endeavors in radioactivity and McClintock's contribution in genetic biology present the possibility of women being successful in the field of science. Knowing about these scientists instills in students the notion that knowledge exploration is universal. Everyone can perform scientific reasoning and investigation if they are willing to try.

The History of Science Conceptual Framework Used in the Study

The conceptual framework for the study integrates key elements of conceptual understanding, procedural understanding, and contextual understanding. The framework (Figure 1) guided the study of science teachers' perception and practices in teaching the history of science. More specifically, it focused the data collection processes (Miles and Huberman, 1994), and anchored the design of the survey (Fowler, 1993) which probed teacher perceptions and practices in inclusion of the history of science in their classrooms.

Figure 1

History of Science Conceptual Framework

1. Conceptual Understanding	Historical elements provide the description, presentation, comparison, or contraction of scientific (a) thoughts, ideas, concepts, notions, plans, schemes; (b) definition, explanations, models, illustrations, graphics, instrumentation; (c) findings, standards, laws, theories to 1.1 Enrich the presentation of scientific knowledge 1.2 Emphasize the tentative nature of scientific knowledge
2. Procedural Understanding	Historical elements provide the descriptions of: 2.1 Process of thinking or thought experiment 2.2 Process of investigation 2.3 Process of concluding, inferring, elaboration, reporting, and application.
3. Contextual Understanding	Historical elements provide the descriptions of : 3.1 Psychological factors involved in the science making (e.g., motivation, incentives, purposes) 3.2 Social factors (e.g., peer influences, public attitudes, social needs, or politic factors that effect on the scientists action to communicate, confirm, confront, or contribute) 3.3 Cultural factors associated to the science research (e.g., personalities, culture of family, organization, social, or ethics, etc.)

Methodology

Sample. Twelve teachers from one elementary school participated in the pilot study for the survey. The survey was then refined based on their feedback. The new survey was then administered during a professional development day offered by the Los Angeles Systemic Initiative (LA-SI). Around three hundred science and mathematics teachers from the Los Angeles Unified School District (LAUSD) participated in the professional development workshops. Thirty-eight participants volunteered to participate in the survey administration. Among the volunteers were twenty-one elementary teachers, two middle school teachers, and fourteen high school teachers. The final survey was discarded because it was not completed in a useable way.

Five teachers were then invited for an extensive interview. The first interviewee taught high school physics for 20 years, including eleven years experience with Harvard Project Physics, an historical physics curriculum. The second interviewee has taught integrated science in a middle school for two years. The third interviewee is a teacher at a K-12 school who currently teaches both middle and elementary classes, and is a mathematics and science coordinator at one of LA-SI science and mathematics offices. The fourth teacher is an elementary school science lead teacher and a member of the California Science Project Leadership Cohort. The fifth interviewee has been teaching special education children at the elementary level for many years. He is also a member of the California Science Project Leadership Cohort.

Instrument. The survey was designed based on the history of science conceptual framework generated in the literature review of this study. The conceptual framework contained three domains of understanding: Conceptual Understanding, Procedural Understanding, and Contextual Understanding. Four items were related to the domain of Conceptual Understanding, three items were under the Procedural Understanding domain, and six items were under the Contextual Understanding domain. These thirteen items were the basis for question clusters focused on teacher perception and practice.

The items in both question clusters were constructed by applying a Likert scale of 0 to 5. In Perception cluster, 0 means *Strongly Disagree* and 5 means *Strongly Agree*. In Practice cluster, 0 means *Rarely Occurred* and 5 means *Occurred Frequently*. Attached to the survey was a history of science information sheet that provided survey participants with general ideas about the history of science, including possible instructional strategies and two sample quotations extracted from physics textbooks (see Appendix A).

Data collection and data analysis. Data sources included: (a) survey responses from thirty-eight teachers in the LA-SI professional development day for science and mathematics teachers of the LAUSD in February of 1998; (b) four taped interviews with selected teachers during the LA-SI workshops, and one additional telephone taped interviews after the workshop.

The survey responses was analyzed for reliability (α) of each question cluster, correlation between the question clusters, linear regression for the R Square value of Perception and Practice, and independent sample t-test for elementary and high school teachers' responses on both Perception and Practice question clusters.

The five interviews were fifteen to twenty minutes in duration and were framed around teacher's perception and practices in using the history of science. Teachers were invited to describe instances of integrating the history of science in their instruction, and to provide a sense of when and why they included this history in their classes. The five interviews were tape-recorded and transcribed. The interview transcripts were then coded for two themes: perception and practice. Then the perception and practice statements were further coded using the History of Science Conceptual Framework to identify statements related to the three domains of understanding through the history of science.

Findings and Discussion

Twelve elementary science teachers completed the pilot survey. Feedback from the teachers helped to refine the instrument. The final survey reached reliability (α) of .904 for the perception question cluster and .949 for the practice question cluster.

Table 1 presents the extent to which teachers perceived the value of including history of science in their classrooms, and the extent to which they actually practices this inclusion. The table includes both mean scores showing the extent of perception and practice, and accompanying standard errors.

Table 1

Teacher Perceptions and Practices Regarding
The Use of the History of Science In Their Classrooms
(N=37)

Sample Item Descriptions of the *History of Science Instructional Survey*	Mean		Std. Error	
	Perception	Practice	Perception	Practice
1. ...help students master scientific concepts or ideas	3.54	(2.52)	.167	.166
2. ...help students master scientific models or explanations	3.59	(2.51)	.157	.189
3. ...help students master scientific definitions, laws, and theories	3.46	(2.74)	.188	.234
4. ...help students understand the tentative nature of scientific knowledge	3.72	(2.74)	.192	.219
5. ...help students develop a systematic thinking process	3.24	(2.45)	.210	.217
6. ...help students develop better questioning skills	3.38	(2.56)	.166	.199
7. ...help students increase their investigation skills (observation, measurement, evaluation, etc..)	3.39	(2.60)	.204	.195
8. ...help students see the motivation, incentives, or purposes of why scientific works were conducted	3.95	(2.88)	.160	.220
9. ...help students understand how social factors or political power is closely related to scientific endeavors	3.73	(2.92)	.192	.227
10. ...help students understand how scientific research can influence the welfare of mankind	4.03	3.30	.171	.226
11. ...help students understand that scientists also work in a community where new knowledge is built on other people's endeavors	4.19	3.08	.139	.217
12. ...help students develop understanding that scientists are not different from any individual, they are human	3.85	3.06	.189	.205
13. ...help students recognize diverse cultural heritage and role models	3.81	3.09	.193	.224

Note: For the mean scores in the perception cluster, 0 means *Strongly Disagree* and 5 means *Strongly Agree*. For the practice cluster, 0 means *Rarely Occurred* and 5 means *Occurred Frequently*. Scores below 3.0 are in parentheses.

Two initial findings are worth reporting. First, teacher views about the value of history of science were related to their practice in using it in their classrooms. A linear regression showed that a teacher's perceptions strongly predicts a teacher's likelihood of practice (F=10.255, Sig. = .003). Second, teachers at the elementary level held views about the history of science that were similar to those of high school teachers. An Independent t-test compared elementary and high school teachers, because the sample of middle school teacher was too small (s=2). There was no significant difference between the responses of high school teachers and elementary school teachers for either their perception about the value of the history of science or about their practice in including it in their classroom.

Table 1 shows that participants valued the importance of integration of the history of science, especially items 8 to13, under the domain of Contextual Understanding in the conceptual framework. These items all have a mean higher than 3.5. In addition, these six items, except item 9, all have practice mean scores higher than 3.0. These results indicate that the teachers perceived that a crucial benefit of the inclusion of science history is the enhancement of Contextual Understanding, and that this aspect frequently happened in their instruction compared to the other two domains: Conceptual Understanding and Procedural Understanding.

Survey and interview data lead to the following key themes:

1. <u>Teachers who believe in and practice the inclusion of the history of science introduce the notion that science is a human endeavor and scientists are human like the rest of us</u>. Teacher Two commented that the historical elements help students relate to science in a personal way:

> The historical instances make science more real to the world. It help students to relate to science better. . . .There were people behind scientific ideas. They will be more motivated when they can relate science more to themselves. (Teacher Two)

Teacher One used Edison as an example to show students how a great inventor like Edison can have personality flaws just like any individual.

When we get to the electricity and magnetism, we talk about things like, Edison would have gotten a Nobel Prize if he wasn't such arrogant . . . because he didn't want to share the prize with Nikola Tesla. (Teacher One)

2. Teachers who believe in and practice the inclusion of the history of science reinforce the idea that scientific research requires intrinsic motivation as well as extrinsic motivation. Teacher One who has taught high school physics for 20 years implied that the history helps students understand that most great scientific works took tremendous effort; the greater the contribution to society, the more it required of scientists:

> I think that one thing that comes out [from the history of science is] that most students begin to realize that scientists really made tremendous contributions to the field, Curie, Einstein, all these people. . .they paid a tremendous price and usually they didn't have much money and they spent all their time focusing on their research. . . .So what's reinforced is if you want to be successful, there's a price. And the more successful you want to be, the more worthy or more important the discovery, the greater the price. . . .Every once a while, a student will come to me and go "Gee, this is the most amazing thing I ever thought about . . .I want to go into physics or something." They changed their mind because they don't want to sell things for the rest of their life. . . .Money is not the most important thing for my students, and they understand that life is more than just live in a bigger house or having a better car. The life has to do with what you think about everyday. It's what you interact with. And what kind of contribution you can make to this society and the people around you. (Teacher One)

3. Teachers who believe in and practice the inclusion of the history of science help students understand how social factors or political power are closely related to scientific endeavors. Having history as undergraduate major, Teacher Two explained:

> I think I included it to explain to kids . . . a little bit of the politics of the time. What I am thinking about is when we were discussing evolution, and when we looked into the study of missing links and Anthropology. At the time, England wanted to be the cradle of civilization. They wanted to discover, they wanted the missing link to come from there so that man would have evolved from the most cultured and advanced civilization . . . (Teacher Two)

4. Teachers who believe in and practice the inclusion of the history of science help students understand that scientists also work in a community where new knowledge is built on other people's endeavors. Teacher Three, who developed lesson units for science teachers to demonstrate the relationships between science, technology, and society,

emphasized how scientific knowledge was cumulative through time and how society benefited from it:

> History gives a platform. A basis to understand why we [learn] certain things in science. When every time I did something with physics, I always tried to get students to understand the basic principles developed by Galileo, Newton, and other scientists. . . .Today, with our technology, so many machines that we have . . .were all built based on ideas of a simple machine and the basic scientific principles behind them are so valuable. . . .If we understand the history behind [science], when it came, how [scientists] go to the next step, next step, and next step . . . we don't have to reinvent the wheel but just to understand how the wheel works. (Teacher Three)

5. <u>Teachers who believe in and practice the inclusion of the history of science help students recognize diverse cultural heritages and role models</u>. Teacher Three cited George Washington Carver as an example to enhance his students' attitude toward science. The majority of his students were African-Americans.

> I was more concerned about attitude when I was teaching elementary students. I want my students to like science. First of all, socially and historically, my students hate science and mathematics. I work on that motivation a lot. . . .I introduced George Washington Carver, who found out that so many things begin with peanuts and made so many inventions. . . .It tells them that they can work on something [important] from things in their life and they can do it. There's no suspicion that they [will] have motivation. (Teacher Three)

Although teachers also think positively with regard to the Conceptual Realm (item 1 to 4) and the Procedural Realm (item 5 to 7), yet their reason and practice for inclusion of the historical elements in their science lessons did not show strongly in these both realms. The interview findings did provide some interesting perceptions and showed some explanations as to the discrepancy between their perceptions and practices.

6. <u>Teachers believe the inclusion of the history of science can be a powerful tool but not for elementary students</u>. Teacher Four believed:

> Discussion of the history of science show people the evolution of understanding. . .I think it is sort of like epistemology . . . the nature of understanding. . . .some kind of idea of everything that we know now somehow had to be learned, just assuming that everything is knowledge but not knowing that knowledge is how human frame the world and not necessarily how the real world is. (Teacher Four)

Teacher Four described the revolutionary ideas of scientific knowledge:

> What I think more important is that the history of science allows students to realize that science is not a body of knowledge that is permanent. It is ever changing, growing, evolving . . . there is a lot to be studied and discovered. In history, . . .what we considered scientific facts, which in maybe twenty years will be refuted after new information being learned. (Teacher Four)

Regarding the difficulty for elementary science teachers to introduce the history of science, Teacher Four and Teacher Five both provided explanations from different standpoints:

> I am at the fifth grade level and I think it is pretty tough . . . for my students to know the history behind the scientific knowledge. Asking these kids to think about the world beyond our neighborhood is really very difficult for me. (Teacher Four)

> I haven't talked about the history of science a lot. Because little kids don't have a sense of time. It is not until they are about 10 to 12 years old that they can even understand what you mean by 100 years ago. I [can] only mention some of the names and I showed them pictures of the equipment that people used. . . Maybe the things that would be more appropriate for my students would be to show them the development of ideas without linking it to a time. (Teacher Five)

The high school teacher, Teacher One also commented on the difficulty of this approach for students who come from families of new immigrants, or students who do not have a western cultural background.

> I think that if kids grow up in this country and their background is US education. . . .kind of being given western civilization the whole way through school, it will be much easier for them to grasp some of the concepts if they are embedded in the history. Because he can go, "Oh, I remember Ben Franklin" when you talked about electricity and current flow . . . that all makes sense to them. Whereas maybe you did not grow up in this country, you didn't have this much background with Ben Franklin for the knowledge to get grounded. (Teacher One)

7. <u>Teachers perceive some benefits of the historical elements for the Procedural Understanding Realm, but found it difficult to practice this.</u> Teacher One explained how historical experiments in science can be included to enhance the scientific process skills if he had more time:

> If you design the experiment to very similar to what's in the historical background, like the Millikan Oil Drop experiment. You show them the film of the Millikan Oil Drop experiment from the Harvard Project curriculum; then you talk about the theory, history, and what he wrote in his notebook about what he did in his experiment; then students do the similar historical experiment. There is no question the students will know more about the processes of doing science. But the trade off is the time spent in doing it this way. (Teacher One)

The time limitation expressed by teachers echoes TIMSS's finding (1996): Teachers attributed the limited inclusion of the history of science to too many topics to be covered in science lessons in a limited amount of time. The instances of using historical elements are perceived as another pedagogical approach with little elaboration.

8. Teachers believed there are too many topics to be covered in the curriculum. The historical elements were introduced only when they could be blended in their current instruction. Teacher Two indicated that the science curriculum for middle school students need to cover lots of instructional materials:

> I do get into a little bit [of history of science]. We try to find focus, because we have to cover a lot of material in integrated science, and it's all of the sciences so that I can only do a little bit of the history. (Teacher Two)

Teacher Four showed how historical elements were used:

> When we studied the moons of Jupiter and at that time Galileo was coming up [in the discussions]. . .so the kids studied about Galileo and his role in that [study of astronomy], how he became a scientist and how he was constantly at odds in the environment of his time. . . .This was there only because it came naturally with the flow of the lesson. I didn't make a conscious effort to teach the history of science. (Teacher Four).

In turn, many valuable aspects of the history of science were excluded because they were not included in the curriculum as learning objectives.

Conclusions and Implications

What does it mean to humanize science? This study reflects the view that humanizing isn't "making it fun" so much as making it a human endeavor. In our paper, we synthesized the literature to capture the historical elements in terms of three realms of human endeavor: conceptual understanding, procedural understanding, and contextual understanding. Teachers were more apt to include historical elements as related to contextual understanding than for the other two realms. We believe that this inclusion enhances the ability of students to enter discussion of public policy about science and the application of scientific findings to social policy.

Historical elements related to the procedural realm were not included nearly as much in the instruction of these teachers. One possible explanation for this finding may reflect a curriculum and instructional limitation—teachers can't see how to make this aspect of their curriculum more human. The net effect could be that students see the work of scientists in human terms when considering public policy, but don't see their own struggle to generate or understand new knowledge in these same human terms. We think teachers could help students distinguish between "errors and inaccuracies" and the process of generating new knowledge where approximation and reformulation are essential.

Teachers believed their curriculum was overloaded with topics, and consequently included the historical elements only when they could be blended with their current curriculum. In this era of TIMSS findings, the overloaded curriculum is a welcomed new mantra in American science education. But, does this mean with a more focused curriculum the historical elements will be discarded along with other non-essentials? In our view, the answer should be "yes and no". Yes, to the extent that the historical elements are add-ons that don't serve vital student understanding.

But "no" in the sense that a focused curriculum will hopefully give more attention to building deep understanding of key student performance standards. To build this understanding, the curriculum will need to move further away from rote facts and procedures. The history of science can humanize student understanding related to these key performance standards—the prospect for the historical elements is enhanced in a focused curriculum.

Reference

American Association for the Advancement of Science. (1993). Benchmarks for Science Literacy. New York: Oxford University Press.

Aldridge, B. (1992). Project on scope, sequence, and coordination: A new synthesis for improving science education. Scope, sequence, and coordination of secondary school science, 2: Relevant research. Washington, DC: NSTA.

Ball, D. L., & Cohen, D. K. (1996). Reform by the book: What is – or might be – the role of curriculum materials in teacher learning and instructional reform? Educational researcher, 25 (9), 6-8.

Bandura, A., & Walters, R. H. (1963). Social learning and personality development. New York: Holt, Rinehart, and Winston.

Becker, B. J. (1997). MindWorks: Making scientific concepts come alive. Paper presented at the 1997 History of Science Society Annual Conference. November, 1997. La Jolla, California.

Brush, S. G. (1974). Should the history of science be rated "X"? Science, 18, 1164-1172.

Bybee, R. W. (1996). The contemporary reform of science education. In J. Rhoton & P. Bowers (eds.). Issues in science education. pp 1-14. Arlington, VA: NSTA.

Champagne, A., & Klopfer, L. E. (1982). Actions in a time of crisis. Science education, 66(4), 503-514.

Conant, J. B. (1951).On understanding science: An historical approach. New York: New American Library.

Conant, J. B. (1957). Harvard case history in experimental science (vol. 1 & 2). Cambridge: Harvard University Press.

Conant, J. B. (1964). Introduction. In J. B. Conant and L. K. Nash (eds) Harvard case histories in experimental science, (1), vii-xvi.

DeBoer, G. E. (1991). A history of ideas in science education: Implications for practice. New York: Teachers College Press.

Duschl, R. A. (1990). Restructuring science education: The important of theories and their development. New York: Teacher College Press.

Duschl, R. A. (1994). Research on the history and philosophy of science. In Gabel, D. L.

(ed.) Handbook of research on science teaching and learning. pp. 443-465. New York: Macmillan.

Dyson, F. (1985). Origins of life. New York: Cambridge University Press.

Fowler, F. J. (1993). Survey Research Methods (7th Ed.). Newbury Park, CA: SAGE.

Gagne, E. D., Yekovich, C. W., Yekovich, F. R. (1993). The cognitive psychology of school learning. New York: Harper Collins College Publisher.

Giannetto, E., Tarsitani, C., & Missoni, M. V. (1991). The relations between epistemology, history of science & science teaching from the point of view of the research on mental representations. In D. E. Herget (ed.) More history and philosophy of science in science teaching, 359-374. Tallahassee, Fl: Florida State University.

Griffiths, A. K., & Barry, M. (1993). High school students' views about the nature of science. School science and mathematics, 93 (1), 35-37.

Holton, G. (Personal communication, November 8, 1997).

Hurd, P. D. (1973). Integrated Science. The science teacher, 40(2), 18-19.

Kaplan, A. (1964). The conduct of inquiry: Methodology for behavioral science. San Francisco, CA: Chandler.

Klopfer, L. E. (1969). The teaching of science and the history of science. Journal of research in science teaching, 6, 87-95.

Klopfer, L. E., & Watson, F. G. (1957). Historical materials and high school science teaching. The science teacher, 24, 264-265, 292-293.

Kuhn, T. S. (1970). The structure of scientific revolutions. 2nd ed. Chicago: University of Chicago Press.

Kyle, W. C. (1991). Curriculum development projects of the 1960s. Research within research: Science Education. 3-24.

Mascolo, R. (1969). Performance in conceptualizing: Relationship between conceptual framework and skills of inquiry. Journal of research in science teaching, 6, 29-35.

Matthews, M. R. (1994). Science teaching: The role of history and philosophy of science. NY: Routledge.

Mendelsohn, E., Weingart, P., & Whitley, R. (1977). The social production of scientific knowledge. Boston, MA: D. Reidel Publishing Company.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis. 2nd Ed. Thousand Oaks, CA: SAGE.

National Commission on Excellence in Education (1983). A nation at risk: The imperative for educational reform. Washington, DC: U.S. Goverment Printing Office.

National Research Council. (1996). National Science Education Standards. Washington DC: National Academy Press.

National Science Teachers Association. (1982). Science-technology-society: Science education for the 1980's. Washington, Author.

New Standards. (1997). Performance standards, Volume 1, Volume 2, and Volume 3. Washington, D.C.: National Center on Education and the Economy.

Pella, M. O., O'Hearn, G. T., & Gale, C. W. (1966). Scientific literacy: Its referents. The science teacher, 33, 44.

Piaget, J. (1970). Genetic epistemology. New York: Columbia University Press.

Quattropani, D. J. (1977). An evaluation of the effect of Harvard Project Physics on student understanding of the relationships among science, technology, and society. Ph.D. dissertation. University of Connecticut.

Rutherford, F. J., & Ahlgren, A. (1990). Science for all Americans: Scientific Literacy. New York: Oxford University Press.

Rutherford, F. J., Holton, G., & Watson, F. G. (1970). *Harvard Project Physics*. New York: Holt, Rinehart, & Winston.

Schmidt, W. H., McKnight, C. C., & Raizen, S. A. (1997). A splintered vision: Investigation of U.S. science and mathematics education. Boston: Kluwer.

Schwab, J. J. (1960). What do scientists do? Behavioral Science, 5, 1-27.

Schwab, J. J. (1962). The teaching of science as enquiry. In J. J. Schwab & P. F. Brandwein (Eds.) The teaching of science. pp.3-103. Cambridge: Harvard University Press.

Schwab, J. J. (1963). Biology Teacher's Handbook. New York: Wiley.

Schwab, J. J. (1964). Science as enquiry. In G. W. Ford & L. Pugno (Eds.) The structure of knowledge and the curriculum. Chicago: Rand McNally.

Snow, C. P. (1962). The two cultures and the scientific revolution. New York: Cambridge University Press.

Villani, A., Arruda, S. (1998). Special theory of relativity, conceptual change and history of science. Science and education, 7(1), 85-100.

Wandersee, J. H. (1990). On the value and use of the history of science in teaching today's science: Constructing historical vignettes. In D. E. Herget (ed.), More history and philosophy of science in science teaching. Florida State University, Tallahassee, FL. pp. 278-283.

Wandersee, J. H. (1985). Can the history of science help science educators anticipate students' misconceptions? Journal of research in science teaching, 23, 581-597.

Wang, H. A., & Marsh, D. D. (1997). Curriculum Conceptions and Science Standards: Partners for Reform. Paper submitted to School science and mathematics.

Wartofsky, M. W. (1968). Conceptual foundations of scientific thought. New York, MaCmillan.

Welch, W. W. (1973). Review of the research and evaluation program of Harvard Project Physics. Journal of research in science teaching, 10, 365-378.

SE061541

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Science Teachers' Perceptions and Practices In Teaching the History of Science	
Author(s): HsingChi A. Wang and David D Marsh	
Corporate Source: University of Southern California	Publication Date: April, 1998

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
[X]	[ ]	[ ]
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: HsingChi A Wang	Printed Name/Position/Title: HsingChi A. Wang	
Organization/Address: 2250 Alcazar ST. CSA 103/HSC Los Angeles, CA 90033	Telephone: (213) 342-3170	FAX: (213) 740-8666
	E-Mail Address: hawang@scf.usc.edu.	Date: 4-15-98

(over)

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

THE UNIVERSITY OF MARYLAND
ERIC CLEARINGHOUSE ON ASSESSMENT AND EVALUATION
1129 SHRIVER LAB, CAMPUS DRIVE
COLLEGE PARK, MD 20742-5701
Attn: Acquisitions

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
1100 West Street, 2nd Floor
Laurel, Maryland 20707-3598

Telephone: 301-497-4080
Toll Free: 800-799-3742
FAX: 301-953-0263
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com